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Dr B R Ambedkar National Institute of Technology, Jalandhar

M Tech-AI 2nd Semester

AI–502, Computer Vision and Natural Language Processing

Mid-Semester Examination, March-2026

Duration: 02 Hours Max. Marks: 30 Date: 10/03/2026

Marks Distribution & Mapping of Questions with Course Outcomes (COs)								
Question Number	1(a)	1(b)	2	3(a)	3(b)	4(a)	4(b)	5
Max. Marks	3	3	6	3	3	3	3	6
CO No.	1	3	1	1	1	1	1	3
*Cognitive Level	U	Ap	E	Ap	An	Ap	An	Ap
**Section/Chapter/Unit	1	3	1	1	3	1	3	3

1. **(a)** Explain the difference between image processing and computer vision. Give two examples where image processing techniques act as preprocessing for computer vision tasks.

   (b) Using finite difference approximations, derive the expression for the second derivative in the x-direction

$$\frac{\partial^2 I}{\partial x^2} \approx I(x+1,y) - 2I(x,y) + I(x-1,y)$$

   and show how combining derivatives in both directions leads to the Laplacian operator.

2. An image contains high-frequency noise and several significant edge discontinuities.

   i. Analyze how a mean filter modifies the local intensity distribution of the image and explain why it suppresses high-frequency components. **(2 Marks)**

   ii. Evaluate the impact of mean filtering on intensity discontinuities, and explain explain its effect on edges. **(2 Marks)**

   iii. In practical edge detection pipelines, a different smoothing operator is usually applied prior to gradient computation. Identify this operator and justify its suitability for edge detection compared to mean filtering. **(2 Marks)**

3. **(a)** Consider the following intensity profile of a 1-D image signal: 10, 10, 10, 50, 50, 50

    i. Compute the finite difference gradient at each position **(1 Mark)**

    ii. Identify the location of the edge using the computed gradient. **(1 Mark)**

    iii. Explain why derivative-based operators amplify noise. **(1 Mark)**

   (b) The Sobel operator uses two directional filters to estimate image gradients. Describe the principle behind this approach and analyze how the G_x kernel reacts when intensity changes occur across adjacent columns of pixels.

4. **(a)** After computing gradient magnitude in an image row, the following values are obtained: 0, 5, 15, 20, 10, 5, 0

    i. Apply Non-Maximum Suppression assuming the gradient direction is horizontal. **(1 Mark)**

    ii. Suppose the high threshold is 15 and the low threshold is 8. Apply hysteresis and determine the final edges. **(2 Marks)**

   (b) Show mathematically why the Difference of Gaussian

$$L(x, y, k\sigma) - L(x, y, \sigma)$$

   approximates the Laplacian of Gaussian in scale-space. Explain why this approximation is computationally more efficient for detecting keypoints in the SIFT algorithm.

5. In many computer vision applications, image features are extracted and compared to determine whether two images contain similar objects.

   (a) Briefly explain how SIFT and HOG descriptors represent local image structure using gradient information. **(2 Marks)**

   (b) Two feature vectors extracted from image patches are given as: $x = (5,4)$, $y = (7,5)$ Compute the Euclidean distance between the two vectors. **(1 Mark)**

(c) Suppose the covariance matrix of the feature distribution is

$$\Sigma = \begin{bmatrix} 4 & 0 \\ 0 & 1 \end{bmatrix}$$

Compute the Mahalanobis distance between the same vectors. **(1 Marks)**

(d) Interpret the difference between the Euclidean and Mahalanobis distances obtained above. How does incorporating the covariance matrix change the way similarity between feature vectors is measured? **(2 Marks)**